

MARTIAN ENVIRONMENTAL EFFECTS ON SOLAR CELLS
AND SOLAR CELL COVER GLASSES

Contract No. 952582

TTU Report 3301- 1st Quarterly

15 October 1969

Prepared by
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Principal Investigator



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Technical Content Statement

This report contains information prepared by Texas Tech University under JPL subcontract. Its content is not necessarily endorsed by the Jet Propulsion Laboratory, California Institute of Technology, or the National Aeronautics and Space Administration.

Abstract

This report presents the progress to date of the work on the project entitled Martian Environmental Effects on Solar Cells and Solar Cell Cover Glasses by the Department of Geosciences, Texas Tech University for the Jet Propulsion Laboratory, Pasadena, California, under Contract 952582, a subcontract of NASA, NAS7-100.

The possibility of dust storms on Mars is recognized as is the possibility of detrimental effects of dust storms to any solar cell array placed at or near the surface of Mars. Solar cells will be subjected to dust storms in wind tunnels where simulated Martian environmental conditions prevail. The electrical performance of the solar cells will be tested before and after each test and the damage to the cells will be assessed. As no tests have been completed, no conclusions or recommendations are presented.

Summary

Various investigators have suggested that dust storms do occur in the rarefied atmosphere of Mars. Because the possibility does exist, it is necessary that the effects of such storms on the performance of solar cells be determined prior to a soft landing on Mars. During dust storms fine particulate matter could be deposited on the cells and the cover glasses could be abraded. In either case the efficiency of the solar cells would be reduced. In order to determine how extensive the damage and blanketing effect to the cover glasses might be and the resulting reduction in their efficiency a series of experiments under predicted Martian environmental conditions has been specified.

A wind tunnel of the "race track" type has been constructed of plastic and will be used in all tests at ambient temperatures.

A second wind tunnel is being constructed of sheet metal. Heating and cooling elements will be provided in order to control the temperature. One series of tests will be run at 245°K and a second series with temperatures reproducing diurnal variations over test periods of up to three days.

Following each test the total transmission of the solar cell cover glasses will be determined and each cover glass will be subjected to microscopic examinations to determine the extent of damage. Current voltage curves will be made before and after exposure to each test in order to evaluate

the effects upon the electrical performance of the solar cells. Cell assemblages will be tested in groups of four with each subgroup having different protective cover glasses, namely, quartz, Corning No. 0211 Microsheet, sapphire and integral.

Preliminary tests with standard glass cover glasses indicates that there will be considerable abrasive damage and that a coating of fine particulate matter will accumulate and thus reduce the electrical performance of the solar cells.

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Introduction

Most observers of Martian atmospheric phenomena accept the suggestion that the yellow clouds are dust clouds. Because no reasonable alternative suggestions have been offered, we must accept the possibility that dust storms do occur in the Martian atmosphere. The effects of wind driven dust and sand particles on equipment to be landed on the Martian surface must be determined. If such effects are detrimental to the operation of the equipment, changes to eliminate these effects must be incorporated in their design.

At present most items of equipment which are flown in space or landed on an extraterrestrial body receive their power from solar cell assemblages. In space or on the lunar surface there are no dust storms so the problem of their detrimental effect has not existed to date. On Mars the problem may exist and equipment may become inoperative for lack of power following a dust storm.

In order to determine the effect of dust storms on solar cells and solar cell cover glasses a series of tests has been designed in which these objects will be subjected to dust storms at specified wind velocities, temperatures or temperature ranges, in a carbon dioxide atmosphere containing a trace of moisture. These tests will be carried out in wind tunnels designed specifically for them. To assess the results the following tests will be made.

- (i) The total transmission of the solar cell cover glasses before and after subjecting them to dust storms.

- (ii) Microscopy of solar cell cover glasses using phase contrast and polarized light techniques.
- (iii) Current voltage curves will be made before and after exposure to dust storms as is necessary to evaluate the effects upon the electrical performance of the solar cell cover glass combinations.
- (iv) Following (iii) cover glasses will be removed and the measurements repeated.

Technical Discussion

Based upon data presented in JPL Document No.606-1, dated July 15, 1968 (1), the Martian environment at or very near the surface is as follows.

Surface pressure - $\sim 10\text{mb}$

Composition of the atmosphere - $>50\%$ CO_2 , the remainder probably an inert gas such as argon, plus or minus trace of water vapor.

Temperatures

Maximum at equator - $\sim 305^\circ\text{K}$

Minimum at equator - $\sim 170^\circ\text{K}$

Mean amplitude of diurnal variation at equator - $\sim 96^\circ\text{K}$

Mean polar cap region (estimated)

Winter - $\sim 220^\circ\text{K}$

Summer - $\sim 265^\circ\text{K}$

The surface material is believed to resemble olivine basalt or tholeiitic basalt. The surface layer is probably composed of unsorted particulate basalt which ranges in size from a few microns to blocks measuring tens of centimeters in dimensions.

Wind velocities based upon observed motions of yellow clouds may range up to 100 km per hour.

In the design of the tests to which solar cells and solar cell cover glasses will be subjected some exceptions to the above specifications were made.

Pressure. Because of the extreme difficulty in maintaining a pressure of 10 mb and wind velocities of up to 100 km/hr in a wind tunnel, it was agreed to use ambient pressures. Actually this will result in "worst case" phenomena during tests. Corrected wind velocities can be determined mathematically.

Atmosphere. The atmosphere will be 100% carbon dioxide + a trace of water.

Temperature. One series of tests will be run at ambient temperatures, a second series at 245°K and a third with a diurnal variation from 210°K to 305°K.

Wind Velocities. One series of tests will be conducted with wind velocity at 50 km/hr, a second at 75 km/hr, and a third at 100 km/hr.

Particulate Matter. The dust particles to be used in the tests were obtained by grinding and sieving olivine basalt which was collected in the Hudson Mountains, Ellsworth Land, Antarctica. The principal constituents are clinopyroxene, plagioclase and olivine. A small amount of glass is present. This differs somewhat from the composition of the fines in the lunar soil obtained by the astronauts of Apollo 11. In the lunar material glass constitutes about 50 percent and ilmenite is a principal constituent (2). These compositional differences should not alter the results of the tests significantly. Wind tunnel tests have shown that movement of particles of less than 60 microns in size will not be initiated by wind velocities of 100 km/hr or less. The presence of slightly larger particles is necessary to initiate movement. These larger particles move by the process of saltation and with every bounce finer particles are knocked into the air stream where they remain in suspension. The fines in the lunar soil material brought to earth by the astronauts in the "bulk box" were composed of approximately 45% in the 125-62.5 micron range and 25% in the less than 62.5 micron range (2). Using these figures as the best available, the mixture to be used in the wind tunnel tests will be composed of 64% 125-62.5 micron particles and 36% of less than 62.5 microns. These are weight percentages.

The schedule of tests is shown in Figure 1.

Wind tunnel No. 1 was completed on Oct. 10, 1969. Preliminary tests are in progress. Complete descriptions of the wind tunnels and their operation will be included in the second quarterly report which will be submitted January 15, 1970.

TEMPERATURES																										
AMBIENT				AVERAGE (245°K)								DIURNAL CYCLE														
SOLAR CELL PROTECTION				SOLAR CELL PROTECTION								SOLAR CELL PROTECTION														
Days	Vel. Km	Atmos. CO ₂	Corning #0211 Micro-sheet		Quartz		Sapphire		Integral Glass Covers		Corning #0211 Micro-sheet		Quartz		Sapphire		Integral Glass Covers		Corning #0211 Micro-sheet		Quartz		Sapphire		Integral Glass Covers	
			A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	50	Dry																								
		Wet								X	X								X	X						
		Dry																								
		Wet	X	X								X	X								X	X				
1	75	Dry																								
		Wet																								
		Dry																								
		Wet			X	X	X	X						X	X	X	X						X	X	X	X
1	100	Dry																								
		Wet																								
		Dry																								
		Wet			X	X	X	X						X	X	X	X				X	X				
3	50	Dry																								
		Wet																								
		Dry																								
		Wet																								
3	75	Dry																								
		Wet																								
		Dry																								
		Wet	X	X								X	X								X	X				
3	100	Dry																								
		Wet																								
		Dry																								
		Wet			X	X	X	X						X	X	X	X						X	X	X	X

A = Expanded silver mesh
 B = JPL bus bar Dwg #10016709-1
 X = First priority experiments

Figure 1. Schedule of Tests

References

1. Mars Scientific Model. JPL Document No.606-1.
July 15, 1968. Prepared by members of the Lunar
and Planetary section.
2. Preliminary Examination of Lunar Samples from
Apollo 11. 1969. Science, Vol. 165, p. 1219.
Prepared by the Lunar Sample Preliminary Examination
Team.